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OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAMME OF THE

CHICAGO MEETING

AT

THE UNIVERSITY OF CHICAGO

CHICAGO, ILLINOIS

November 21–22, 1941

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NOVEMBER 5, 1941 Vol. 16, No. 5

BULLETIN

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AMERICAN PHYSICAL SOCIETY

CHICAGO MEETING, NOVEMBER 21–22, 1941

THE 244th regular meeting of the American Physical Society will be held at the University of Chicago, Chicago, Illinois, on Friday and Saturday, November 21 and 22, 1941. Sessions will occur in Eckhart Hall, the first commencing at 10:00 on Friday morning.

Hotel. The Windermere Hotel, 1642 East 56 Street, near the campus, offers single rooms at $3.50 per night, double rooms at $5.00. Reservations should be made as early as possible, by letter to the hotel. Members are reminded that it is the practice of hotels not to hold reservations into the evening hours, unless specifically so requested (with an indication of the presumptive hour of arrival of the guest).

The **dinner** will be a joint dinner of the American Physical Society and the Physics Club of Chicago. It will be held on Friday evening at 6:30 o'clock in the International House. The price will be $1.60 per plate including tip. Tickets for the dinner must be bought before Friday noon.

Annual Meeting. The Physical Society and the Association of Physics Teachers will meet at Princeton, New Jersey, on Monday, Tuesday, and Wednesday, December 29, 30, and 31, 1941. It is highly probable that the Society will be able to confine its programme to Tuesday and Wednesday, and the Association to confine its programme to Monday and the morning of Tuesday, except for a joint session which is planned for Tuesday afternoon. At this joint session it is hoped that President G. W. Stewart will deliver his retiring presidential address, that Professor W. F. Magie of Princeton University will speak on the life and work of Joseph Henry, and that Professor A. H. Compton of the University of Chicago will deliver the first Richtmyer Memorial Lecture (of the A.A.P.T.) on "Wartime Problems of the Physics Teacher." One or another of these lectures may be given at some other time during the three days. The local committee recommends the Princeton Inn and the Nassau Tavern, where the rates will be of the order of $3 per day single and $5 double.

GENERAL RULES RELATING TO PAPERS

By vote of the Society on December 27, 1940, no paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

NOV 7 1941

After the Chicago Meeting subsequent meetings are planned as follows:

245. December 19–20, 1941. Pacific Coast Meeting. Stanford University, California.
246. December 29–31, 1941. Annual Meeting. Princeton, New Jersey.
247. February 20–21, 1942. Detroit, Michigan.
248. April, 1942. Time and place to be designated.
249. June, 1942. Pacific Coast. Time and place to be designated.
250. June, 1942. State College, Pennsylvania.

KARL K. DARROW, *Secretary*
Columbia University, New York, New York
November 5, 1941.

CALENDAR

Friday morning, November 21
10:00 o'clock: Eckhart 133: Papers 1–11. See pages 5–7.
10:00 o'clock: Eckhart Commons Room: Meeting of the Council.

Friday afternoon, November 21
2:00 o'clock: Eckhart 133: Papers 12–21. See pages 7–8.

Friday evening, November 21
6:30 o'clock: International House: Joint dinner with the Physics Club of Chicago.

Saturday morning, November 22
10:00 o'clock: Eckhart 133: Papers 22–30. See pages 9–10.
To be read by title: Papers 31–32. See page 11.

PROGRAMME

FRIDAY MORNING AT 10:00 O'CLOCK

Eckhart 133

1. Statistical Distribution of Impedance Elements in Biological Systems. A. M. WEINBERG AND A. S. HOUSEHOLDER, *University of Chicago.*—Electric impedance measurements on systems consisting of non-uniform elements (e.g., nerve bundles, cell suspensions, imperfect dielectrics) can be interpreted if the impedance characteristics of the individuals and their impedance distribution is known. Conversely, given the observed over-all impedance, $z(p)$, the impedance distribution of the individuals is not uniquely determined in both phase angle and static capacitance. If all individual phase angles are equal, the distribution, $D(\tau)$, is the solution of Stieltjes' integral equation

$$F[z(p)]=\int_0^\infty \frac{D(\tau)d\tau}{1+p\tau},$$

F being a known function of the geometry of the system. It is shown that the phase angle of the equivalent suspension approaches that of the original suspension as the dispersion of $D(\tau)$ decreases.

2. Kinetic Theory of Mechanical Forces in Diffusion Fields. H. D. LANDAHL, *University of Chicago.*—The mechanical forces in diffusion fields are of interest in mathematical biophysics of cell division and other phenomena in metabolizing systems. Some insight into the problem may be gained by considering the force on a particle in a non-uniform, dense mixture of gases. For this reason, an expression was derived for such a force. Three types of terms arise under the assumptions made. One is due to the mass velocity of the system, one arises because of the finite sizes of the particle and molecules, and one arises because of the dependence of collision frequencies on the density, which varies in space. Each term is proportional to the density gradient if the mass velocity is due only to diffusion. The expression for the force is compared with an analogous expression arrived at by considering incompressible fluids passing through each other,[1] and obtaining the resulting force on a particle at rest suspended in the mixture.

[1] G. Young, Bull. Math. Biophysics **2**, 145 (1940).

3. Excitation of the Anode Effect. PAUL L. COPELAND AND GERALD G. CARNE, *Illinois Institute of Technology.*—The way in which charge trapped on the grid surface of an experimental triode accumulates has been observed by collecting relatively large grid currents for various short time intervals and studying the resulting changes of plate current. If the shift of the contact potential of the grid is plotted against the logarithm of the time that the grid collects current, a graph which is linear over a considerable interval results, and in this respect the curves showing the accumulation of the charge resemble those showing its decay. If the total charge collected by the grid be denoted by Q_p and the total charge trapped on the grid be denoted by Q_c, the observed results are consistent with the empirical formula $Q_c=Q_p/(A+mQ_p)$, where A and m are constants depending on experimental conditions. The charge accumulating on the grid approaches the limit $1/m$, and this quantity decreases as the grid temperature increases. A, representing the limit of the ratio of the collected charge to the trapped charge when, starting with the equilibrium state, the collected charge is made very small, also varies with the temperature of the grid.

4. Thermionic Properties of the Iron Group. H. B. WAHLING, *University of Wisconsin.*—The pyrometer temperature scales of the iron group have been determined as a preliminary to the thermionic studies. A change in the emissivity of iron at the crystal structure transition point has been observed. This serves as a new method of determining the temperature of this charge. The work functions of the metals have been determined and the effect of certain impurities in Ni determined. A difference of 0.25 volt has been observed in the work functions of β- and γ-iron. The work function of pure Ni has been found to be 4.61 volts and that of Co 4.42 volts.

5. Theory of the Magnetron. LEON BRILLOUIN, *University of Wisconsin* (*Introduced by Karl K. Darrow*).—In a first paper recently published in *The Physical Review* [**60**, 385–396 (Sept. 1, 1941)] the author studied theoretically the comportment of a magnetron under steady conditions, and attempted to calculate the conditions for sustaining continuous oscillations by a magnetron with one cylindrical anode. The present paper relates to the problem of the magnetron with an even number of anodes. In order to avoid too much complication in the calculations some simplifying assumptions have been made, neglecting the radius of the filament and ignoring the role of oscillating magnetic fields; the limitations due to such simplifications are discussed, and it may be proved that they are justified in most cases. The theory shows under which condition this type of magnetron should yield a negative resistance and be able to sustain oscillations in an outer circuit.

6. An Electronic Stabilizer for 1 to 50 kv and 20 to 500 ma. J. W. TRISCHKA AND L. G. PARRATT, *Cornell University.*—An electronic stabilizer for use in the output of a high voltage d.c. power supply has been developed which is proposed as a satisfactory and economical solution of the problem of obtaining very large powers which are stable over a wide range of voltages and currents (1 to 50 kv and 20 to 500 ma in the present design). The device reduces the residual ripple and fluctuations in the load current as well as stabilizes against fluctuations in the

input voltage. This stabilizer is capable of maintaining for several hours an output voltage constant within ±0.3 percent when the input fluctuates by ±5 percent. The largest source of output fluctuation is a slow drift. The apparatus, containing an 833-Type tube with two stages of amplification in the grid circuit, is essentially a modification of the degenerative type of stabilizer, but, taking advantage of grid current, may be adjusted to have positive, negative, or infinite, stabilization ratio.

7. X-Ray Absorption Structure in the Region of the Potassium K Edge. J. B. PLATT AND L. G. PARRATT, *Cornell University.*—Variations of the absorption coefficient of potassium near the K edge have been measured with a two-crystal vacuum spectrometer. The measurements of the transmitted beam intensity are accurate to within 1 percent of the intensity of the incident beam. The spectral region has been carefully studied from six electron volts less than the energy of the K edge to thirty electron volts greater than that of the K edge. Calcite crystals on the spectrometer gave a computed resolving power of about 12,000. Absorber "sandwiches" were prepared by evaporating a protective layer of 200A of aluminum on a Kodapak base, evaporating 80,000A of potassium, and finally evaporating a coating of Ceresine wax on the potassium surface to prevent oxidation when exposed to air. Results are in agreement with theoretical predictions based on the free electron approximation to the energy bands in metallic potassium.

8. Further Theoretical Studies of the Temperature Diffuse X-Ray Scattering. W. H. ZACHARIASEN, *University of Chicago.*—The general intensity formula for the temperature diffuse scattering[1] has been studied in greater detail. In order to make exact numerical calculations for the diffraction pattern it is necessary to know the propagation velocities and the polarization directions of the proper vibrations throughout the entire vibrational spectrum. Calculations have been carried out for simple lattice models. It is found that the details of the diffuse diffraction pattern vary considerably as the elastic properties of the lattice model are changed. The calculations can be directly compared with experimental data obtained with simple crystals like rocksalt and sylvine. In all cases where such detailed comparisons have been made the agreement between theory and experiment is complete. Because the acoustical frequency branches are more important for the diffuse scattering than the optical branches calculations based upon monatomic lattice models may be used for qualitative and semi-quantitative interpretation of experimental data obtained with crystals of more complex structure. Thus theory can account for the puzzling effects reported for diamond.

[1] W. H. Zachariasen, Phys. Rev. **57**, 597 (1940).

9. On the Lattice Vibrations of the KCl Crystal. MARIO IONA, JR.,* *University of Chicago* (*Introduced by W. H. Zachariasen*).—The distribution of characteristic vibrations of the KCl crystal has been calculated following Born, v. Kármán, and Blackman under the assumption of both electrostatic and repulsive forces between the ions. The former have been calculated according to Waller following the method of Ewald. Following Ljunquist the elastic constants and the residual ray frequency have been used to determine four force constants of the repulsive forces for the interaction of 18 nearest neighbors. The distribution obtained in this way shows a relatively great number of vibrations above the residual ray frequency, a feature which has been pointed out in other works in which the electrostatic effect was considered. These higher frequencies however do not influence the specific heat, which is determined mainly by the two maxima of the distribution function and which has a minimum for absolute temperatures of about 15° in accordance with the experimental results of Keesom, Clark, and Lindemann.

* Also at University of Uppsala (Sweden).

10. A Comparison Between a Geiger-Mueller Counter, a Secondary Electron Multiplier Tube, and Photographic Film for Detecting Weak X-Rays. A. EISENSTEIN AND N. S. GINGRICH, *University of Missouri.*—A Geiger-Mueller (G-M) counter and a secondary electron multiplier (S.E.M.) tube, both designed for use with x-rays, were compared for use in detecting x-rays. Each tube was used under optimum operating conditions and the x-ray intensities in the two cases were known to be approximately equivalent. The rate of counting was determined by means of an amplifier and scaling circuit. Amplified pulses from the G-M tube had a resolving time of about 10^{-3} sec., and those from the S.E.M. tube, about 8×10^{-6} sec. Both tubes were shown to respond linearly to intensity over a wide range of intensities. The relative response of the tubes (G-M to S.E.M.) at several wave-lengths was found to be: at 0.631A, 10.71; at 0.708A, 9.77; at 0.712A, 9.98; at 1.39A, 5.0; at 1.54A, 4.92. This shows that the G-M tube is from 5 to 10 times as sensitive as the S.E.M. tube and that the S.E.M. tube sensitivity changes more rapidly with wave-length than that of the G-M tube. A qualitative comparison between the G-M tube and photographic film showed that a complete diffraction pattern of a liquid could be obtained with the G-M tube in about one-twentieth the time required in the photographic method.

11. A Two-Dimensional Phase of Peculiar Properties. WILLIAM D. HARKINS, L. E. COPELAND, AND G. E. BOYD, *University of Chicago.*—If the most condensed two-dimensional liquid (L_2) previously known is compressed isothermally, it transforms to what has been considered as a solid (S) phase, of much lower compressibility, without a latent heat of freezing (second order change). In an attempt of the senior author to discover a first order change in a two-dimensional system, a remarkable SL phase has been found. It was first noted that if the process of its formation from L_2 is freezing, this occurs by addition of heat. Then it was found that the SL phase has the extremely low compressibility of the S phase, but is a superliquid in the sense that its viscosity is very much smaller

than L_2 from which it is formed. The increase of internal energy, of entropy, and the heat absorbed, when this phase expands, are excessively high. The logarithm of the viscosity of the L_2 phase normally increases linearly with the pressure, but if the LS phase instead of the S phase is to form, the viscosity decreases with extreme rapidity with the pressure. The temperature of the transformation from L_2 to SL increases about 5° per carbon atom in the molecule. With a new apparatus monolayers will be investigated from 0° to −20°C.

FRIDAY AFTERNOON AT 2:00 O'CLOCK

Eckhart 133

Cosmic Rays and Nuclear Physics

12. A Statistical Study of Cosmic-Ray "Star" Tracks in a Photographic Emulsion. MAURICE M. SHAPIRO, *University of Chicago* (*Introduced by Arthur H. Compton*).—To obtain data concerning the multiple nuclear disintegrations produced by the cosmic radiation, special photographic plates were left on Mt. Evans for nearly eight months. From a statistical investigation of 365 tracks in 142 "stars" found in one of these emulsions, it is estimated that more than 90 percent of the tracks were produced by protons. Most of the remaining star tracks are probably due to alpha-particles.

13. Cloud-Chamber Photographs at 14,170 Ft. Altitude. W. H. BOSTICK, *University of Chicago* (*Introduced by Arthur H. Compton*).—A cloud chamber 24 cm in diameter with a 1.3-cm lead plate in the middle was used in turn under 12.7 cm and 20 cm of lead, and was tripped with a shower arrangement to look for mesotrons in air showers at 14,170 ft. altitude. In air showers particles were found which did not produce secondaries in the 1.3-cm lead plate. These particles are classified as heavier than electrons, probably mesotrons. Out of 3041 successful expansions 172 particles are classified by their range and estimated specific ionization as either slow mesotrons or slow protons. 39 particles show a marked increase in ionization on passing through 1.3 cm of lead. 54 particles appear to be penetrating pairs and thus indicate the production of penetrating secondaries at this altitude. Some photographs give evidence of nuclear processes associated with showers. 5 photographs could possibly be explained by the theory of the disintegration of the mesotron.

14. Mass of the Meson by the Method of Momentum-Loss. RUDOLF LADENBURG AND JOHN A. WHEELER, *Princeton University*.—Observations on the curvature of the track of a meson before and after traversal of a known amount of matter allow a determination of the mass of the particle. A discussion is presented of the accuracy and advantages of this method of measuring mass, the principle of which is well known but has so far been little used. In this connection the stopping power for fast particles has been computed on the basis of recent experiments of R. R. Wilson. Curves are presented for the dependence of range on energy and momentum for swift hydrogen and helium nuclei as well as for mesons. The method of momentum loss is illustrated and values are obtained for the mass of the meson from measurements published by Anderson and Neddermeyer in 1934. The evidence available from these mass determinations and from those published by other authors shows the necessity for many more mass determinations before one can decide whether there is a distribution of masses of the meson or not.

15. Mesotron and Electron Energy Spectrum at 14,260 Feet Altitude from Absorption Measurements in Lead. DAVID B. HALL, *University of Chicago* (*Introduced by A. H. Compton*).—The absorption curve for lead at Mt. Evans, Colorado, was obtained for vertical cosmic rays by combining two independent sets of data of threefold and fourfold counter tube coincidence arrangements. Zero to 91 centimeters of lead were placed between the counters, and corrections for air showers were made for each thickness. For small thicknesses of lead the mesotron and electron components were distinguished by means of additional experiments in which showers arising from electrons traversing the vertical counters were detected. The intensity of the electron component was found to be less than 2 percent of the total intensity at 7.5 centimeters of lead, 10 percent at 1.5 centimeters of lead, and at 0 centimeters was estimated to be 30 percent. From this the mean energy of these electrons is seen to be approximately $5 \cdot 10^7$ ev. The lower limit of mesotron energy required for traversing the lead was calculated for each thickness and by applying this to the absorption curve an energy spectrum for mesotrons was obtained extending from 0 to 1.5×10^9 ev. A sharp maximum in the spectrum appears at a considerably lower energy than the maximum observed at sea level.

16. Production of Penetrating Particles on Mt. Evans. VICTOR H. REGENER, *University of Chicago*.—The production of penetrating particles in the cosmic radiation was investigated on Mt. Evans, Colorado (4300 m) during September, 1941. The apparatus consisted essentially of seven counter trays, each containing from 13 to 19 G-M counters of 1″ and 2″ diameter. The trays were arranged below 1, 5, 5, 5, 10 and 10 cm of lead or iron. For studying

the cross section and multiplicity of the production process and the penetrating power of the produced particles, the counters were connected to individual neon lamps. The neon lamps were controlled by their corresponding counters only in the moment coinciding with a vertical fourfold coincidence in the apparatus. A camera, set off by the same coincidence, photographed the neon lamps on 16-mm film. A preliminary survey of the results shows multiple production of penetrating particles by a non-ionizing radiation, as one should expect from the results of former measurements.

17. The Variation of Intensity of Cosmic Rays with Zenith Angle at 14,200 Feet Altitude. MARCEL SCHEIN, DAVID B. HALL, AND JANE HAMILTON-HALL, *University of Chicago.*—The zenith angle intensities of cosmic rays at 15°, 28.5°, 44°, and 59° from the vertical were measured with four similar counter telescopes using 0, 4 and 15 centimeters of lead. Corrections were made for side showers at each angle. Changes of intensity due to barometric pressure were found to be very large for zero centimeters of lead. These variations were averaged out by repeating frequently measurements of two hours duration for each angle. The intensity for each thickness of lead decreased with increasing zenith angle θ approximately following a $\cos^2\theta$ curve, but sharpening for angles greater than 15°. The deviations for 0, 4 and 15 centimeters were, respectively, 6 percent, 8 percent, and 4 percent at $\theta=28.5°$, and 19 percent, 22 percent, and 4 percent at $\theta=59°$. From energy measurements at this altitude it is estimated that the particles recorded between 0 and 4 centimeters of lead consist of approximately 70 percent electrons and 30 percent mesotrons. With 4 centimeters of lead the electron component is reduced to 5 percent of the total intensity. The similarity of the zenith angle curves at 0 and 4 cm of lead indicates that at 14,200 feet altitude a large part of the electron component is in equilibrium with the mesotrons.

18. Radioactive Isotopes of Nickel. MARTIN E. NELSON, M. L. POOL, AND J. D. KURBATOV, *Ohio State University.*—The isotopic assignments of the 2.6-hr. and the 36-hr. periods in nickel are somewhat uncertain, as shown by experimental evidence and by empirical predictions. Hilger H.S. nickel metal was bombarded with 10 Mev deuterons. The 2.6-hr. activity in the separated nickel fraction was followed from 23,000 times background to one-half of background. The 36-hr. activity was not found and, if present, had an intensity less than 0.01 percent that of the 2.6-hr. period. Hilger V.P.S. cobalt metal was also activated with deuterons to test the possible $Co^{57,\,59}$ $(d,2n)Ni^{57,\,59}$ reactions. A weak 2.5-hr. activity, due to a trace of nickel in the cobalt target, was found in the nickel fraction. Again the 36-hr. activity was absent and, if present, had an intensity less than one-tenth background. This is consistent with the recently reported non-existence of stable Co^{57}. Bombarding nickel with fast neutrons gave both periods, while slow neutrons gave only the 2.6-hr. period. The presence of slow neutrons in the fast neutron radiation and vice versa was measured. The above data are best interpreted by assigning the 36-hr. period to Ni^{57} and the 2.6-hr. period to Ni^{63}.

19. Further Progress on the Study of the Radioactive Isotopes of the Nd-Il-Sm Region. J. D. KURBATOV, D. C. MACDONALD, M. L. POOL, AND L. L. QUILL, *Ohio State University.*—Since the previous report[1] on this study, the following additional data have been secured: A. The reactions, Sm+d, Sm+n (fast) and Nd+α, produce the isotopes tentatively assigned to the element samarium, as follows: (a) the isomers 21 ± 2 min., β^- -1.8 Mev emitter and 60 ± 6 days, γ^- emitter; and (b) a 47 ± 1 hr., β^- low upper limit energy emitter. The short period of about 2.4 min., β^+ emitter was always present but cannot be definitely assigned as yet. B. The reactions, Nd+d, Nd+n (fast), Nd+γ, and Pr+p, produce the isotopes assigned to the element neodymium, as follows: (a) a 2.5 hr., β^+ 0.78 Mev emitter assigned to Nd^{141}, (b) a 41 ± 1 hr., β^- 2.9 Mev emitter. Two additional periods, one of about 2 hr., β^- emitter, and the other a short one, are being studied. C. The reactions, Pr+α and Nd+d, produce an isotope >100 days, β^- emitter. The Nd+α, Nd+d, and Nd+γ reactions produce a β^- emitter of about 10 days half-life, and possibly two shorter period substances. Additional studies are in progress to clarify further the assignments of periods to the proper isotopes of Nd, Il, Sm.

[1] H. B. Law, M. L. Pool, J. D. Kurbatov and L. L. Quill, Phys. Rev. **59**, 936 (1941).

20. Deuteron-Tritium Reaction in Nitrogen and Fluorine. LYLE B. BORST, *University of Chicago* (*Introduced by S. K. Allison*).—The deuteron-tritium reaction has been reported for several elements including H^2, Be^9, Cu^{63}, Ag^{107}, and Sb. The following reactions have been established in nitrogen and fluorine:

$$N^{14}\,(d,H^3)\,N^{13} \qquad Q=-4.5\pm0.2 \text{ Mv}$$
$$F^{19}\,(d,H^3)\,F^{18} \qquad Q=-4.1\pm1.1 \text{ Mv}.$$

No such reactions have been found, however, in aluminum and phosphorus, using 8.2-Mv deuterons. Excitation functions have been measured and the thresholds were found to be 6.8 ± 0.1 Mv for nitrogen; 6.6 ± 0.2 Mv for fluorine. The percentage of the barrier height at which H^3 particles may escape is estimated to be: 58 percent for nitrogen; 66 percent for fluorine; and >76 percent for aluminum.

21. A Note on a Problem of Rayleigh. MING CHEN WANG AND G. E. UHLENBECK, *University of Michigan.*—Rayleigh (*Scientific Papers*, Vol. 3, p. 473) has considered the problem of the approach to the equilibrium distribution of a particle of mass M moving in a dilute one-dimensional gas of particles of mass m. He gave the explicit solution for the case $m/M\ll1$; it is an illustration of the Brownian motion of a heavy particle. We have solved the problem for the case $m/M=1$; it gives an illustration of the slowing down of a neutron moving in paraffin. Pictures of the approach to the equilibrium distribution will be shown for both cases.

SATURDAY MORNING AT 10:00 O'CLOCK

Eckhart 133

Spectra

22. Resonance Interaction in the 2200 cm^{-1} Region in the Raman Spectra of Acetylenes. FORREST F. CLEVELAND AND M. J. MURRAY, *Illinois Institute of Technology.*—Continuing investigations of the multiplicity of lines obtained near 2200 cm^{-1} in the Raman spectra of disubstituted acetylenes, as contrasted with the single line usually observed for monosubstituted acetylenes, data (including depolarization factors) have been obtained for butyne-1, hexyne-3, octyne-4 and 1-chloro-heptyne-1. The resonance doublet 2234(6)*P*, 2312(6)*P* in butyne-2 appears at 2231(9)0.4, 2301(6)0.4 in hexyne-3, at 2234(10)0.6, 2292 (6)0.6 in octyne-4 and is replaced by a single strong line at 2242(10)0.4 in 1-chloro-heptyne-1. The disappearance of the doublet in 1-chloro-heptyne-1 suggests that its presence for dialkylacetylenes may be due to a CH_2 or CH_3 group on *each* side of the triple bond. A puzzling feature is the appearance of the strong line at 2247(8)0.4 in the spectrum of hexyne-3. This line appears with small intensity in the spectra of all the other dialkylacetylenes measured in this laboratory, with the exception of octyne-4 for which it is unexpectedly absent. It has also not been reported in the spectrum of butyne-2 which has been studied by several investigators. The spectrum of butyne-1 is interesting in that it is one of the two monosubstituted acetylenes that have been found to have *two* strong lines (2114(10), 2153(3)), rather than the usual *one*, which for monoalkylacetylenes is near 2118 cm^{-1}.

23. Raman Spectra Evidence for Hindrance of Resonance by Ortho Substitution. ROBERT H. SAUNDERS, M. J. MURRAY AND FORREST F. CLEVELAND, *Illinois Institute of Technology.*—If two ortho methyl groups are introduced into coplanar molecules such as nitrobenzene, acetophenone, benzoyl chloride, or methyl benzoate, the Raman line characteristic of the carbonyl or nitro group is shifted to higher frequencies. This effect is apparently due to a rotation of the group about the bond connecting it to the ring, thus resulting in a minimization of the contributions of those resonating forms which, according to modern concepts, may exist only if the molecule is coplanar. The frequencies in the ortho substituted compounds approach the values for the corresponding benzyl derivatives in which the interaction between the carbonyl or nitro groups and the ring is known to be quite small. An exception to the above is benzaldehyde. In this case, substitution of two methyl groups in the ortho positions does not increase the carbonyl frequency; instead, a lowering is observed. This can be understood by supposing that the aldehyde group is small enough to lie in the plane of the ring, thus giving rise to resonance interaction despite the ortho methyl groups. The above conclusions are consistent with those drawn from dipole moment data for the same compounds.

24. Raman Spectra of *dl*- and *meso*-2,3-Dibromobutane. H. J. TAUFEN, M. J. MURRAY, AND FORREST F. CLEVELAND, *Illinois Institute of Technology.*—Raman spectra, including depolarization factors, have been obtained for *dl*- and *meso*-2,3-dibromobutane, molecules differing only in the relative spatial arrangements of the various groups. The *dl* modification yields a greater number of Raman lines, two lines being observed for this form to one for the *meso* in regions near 470, 840, 960 and 1450 cm^{-1}. The line at 1171 cm^{-1} in the *meso* appears to have no analog in the *dl* spectrum and near 1380 the *meso* spectrum has two lines and the *dl* only one. These differences are attributed to the variant symmetry of the two diastereoisomers. A multiplicity of lines in the region attributed to vibrations involving the C-Br group indicates the presence of rotational isomers. Assuming that only "staggered" isomers exist, two rotational forms are possible for the *meso* compound, while three possibilities exist for the *dl* racemate. The spectra reveal two lines in the C-Br region for the *meso* and three such lines for the *dl* isomer. Assignment of these lines to the various rotational isomers is made on the basis of previous spectroscopic work in the field.

25. Intensity Anomalies by Collisions in Perturbed Rotational Bands. H. BEUTLER AND M. FRED, *University of Chicago.*—G. Herzberg reported in 1928 that the cyanogen bands exhibit a strong enhancement of the lines originating from $b^3\Sigma$, $v=0$, $K=4$, 7 and 15, if excited by active nitrogen. H. T. Byck confirmed this result and added that the effect decreases with rising pressure. New photographs of the bands in higher resolution reveal strong extra lines from perturbing levels, in addition to the above enhanced lines. These new lines are also apparent on pictures taken by J. U. White in absorption. Analysis shows the perturbing levels to be $^3\Pi_{\frac{1}{2}}$, $v=9$, $J=15\frac{1}{2}$ and $^3\Pi_{3/2}$, $v=9$, $J=3\frac{1}{2}$ and $7\frac{1}{2}$. The enhancement in emission can be explained by collisions of the second kind among molecules in the mutually perturbing levels for which conditions of close resonance hold. In $^3\Pi-{}^2\Sigma$ bands (red CN system) in emission, a corresponding weakening is expected. Calculations on the collision processes indicate that the enhancement of the $^2\Sigma-{}^2\Sigma$ lines is restricted to medium pressures and disappears for very low and high pressures. The enhancement is related to the ratio of the radiation lifetimes of the unperturbed $b^3\Sigma$ and $^3\Pi$ levels.—A corresponding weakening of perturbed rotational levels is known in other bands, and sometimes explained by accidental predissociation.

26. The Perturbations in the $b^3\Sigma$, $v=0$ Band of Cyanogen. A. T. WAGER, *University of Chicago.*—The (0,0) band of the blue cyanogen system has been photographed with a resolving power of 300,000. The light source was the

flame of $CHCl_3$ in active nitrogen, which gives low rotational levels strongly and enhances the perturbed and perturbing levels, that have been explained as belonging to the $^2\Pi$, $v=9$ system.

The measurement of the plates revealed the positions of the perturbing levels relative to the undisplaced ones, as follows: $\Delta\nu=-0.340$ cm^{-1}, $+0.926$ cm^{-1}, and $+1.276$ cm^{-1} for $K=4$, 7, 15 respectively. The R- and P-lines up to $K=7$ are sharp and single; from $K=7$ through $K=14$ they are wider and appear to be unresolved doublets, thus confirming that the perturbing level $K=7$ is a Π state. The lines from $K=15$ to 19 are clearly resolved doublets with $\Delta\nu=0.22$ cm^{-1}, proving that the perturbation with $K=15$ is likewise a Π level. The lower components of the doublet levels lie on the continuous curve defined by the levels with $J<14$, the higher components on a parallel curve. From the fact that $^2\Pi_{3/2}$ with $J=15\frac{1}{2}$ is the perturbing sublevel, it follows that the perturbed level in $b^2\Sigma$ is $K=15$, $J=K+\frac{1}{2}=15\frac{1}{2}$. Hence, all the shorter wave-length components of the spin doublets for $K>15$ in the 0−0 band of cyanogen have $J'=K'+\frac{1}{2}$, the other ones $J'=K'-\frac{1}{2}$.

27. Rotational Structure of Some Bands of Chlorine Dioxide. JESSE B. COON, *University of Chicago.*—The rotational structure of four bands in the region λ4200–λ4700 has been partially analyzed. The bands correspond to the vibrational transitions[1] $(0, V_2', 0)\leftarrow(0, 0, 0)$ with the breathing vibration $V_2'=1, 2, 3, 4$. Each band has a sharp head shaded toward the red. The tails of these bands are partially resolved showing five to nine sub-bands each containing one strong branch, of which about eight members can be picked out. Term values of the form $F=BL(L+1)+CK^2\pm\frac{1}{2}\gamma_K(K^2/L)$ explain the structure reasonably well. Preliminary analysis indicates that the above lines correspond to a qQ branch of a prolate symmetrical top with parallel type structure showing spin doubling. The values of K for observed sub-bands range from nine to eighteen approximately. The second differences in the K structure are found to be $2(C'-C'')=1.21$ cm$^{-1}\pm0.02$. The second differences in the L structure increase approximately linearly with the vibrational quantum number varying from $2(B'-B'')=0.068$ cm$^{-1}\pm0.002$ for $V_2'=1$ to 0.077 cm$^{-1}\pm0.002$ for $V_2'=4$. $\gamma_K'-\gamma_K''$ is 0.110 cm^{-1} ±0.002. This rotational analysis is consistent with the earlier proposed vibrational analysis.[1]

[1] J. B. Coon, Phys. Rev. **58**, 926 (1940).

28. Absorption Spectrum of Sym-Trichlorobenzene Vapor. H. SPONER AND MAURICE B. HALL, *Duke University.*—The absorption spectrum of sym-trichlorobenzene in the region 2865–2620A was photographed with the Hilger spectrographs E_1 and E_2. The absorption consists of several groups of mostly diffuse bands appearing on a weak continuous background. The bands are degraded to the red. As in benzene the system represents a forbidden transition. It is interpreted as a transition $A_1'\rightarrow A_2'$ made possible when vibrations of type ϵ' distort the molecule. The bands at 35869 and 35073 are tentatively assigned to the $0\rightarrow1$ and $1\rightarrow0$ transitions of an ϵ' vibration, more specifically to the Raman frequency of 425 cm^{-1}. This gives a frequency value of 371 cm^{-1} for this vibration in the excited state. The interpretation is supported by the appearance of bands displaced to the red from the main bands by $425-371=54$ cm^{-1}. The forbidden 0, 0 band is calculated at 35498 cm^{-1}. Frequencies of 963 and 1122 cm^{-1} are considered as belonging to totally symmetrical carbon vibrations in the upper state. A second stronger absorption region occurs below 2250A. It may be discussed in comparison to the second benzene absorption around 2000A.

29. Nature of the Methyl Iodide Absorption System near λ2000. R. S. MULLIKEN, *University of Chicago,* AND EDWARD TELLER,* *Columbia University.*—Extensive analogies between ultraviolet transitions of several groups of molecules, especially the hydrogen- and alkyl-halides, indicate that B and C systems involve analogous electronic transitions in all (W. C. Price). In the hydrogen halides the band structures indicate excited states $(np\pi)^3ms$ $^{1,3}\Pi$, $m=n+1$ with coupling which varies from jj like for HI to nearly LS like for HCl. The methyl iodide B and C systems (the former near λ2000) should have upper states similar to the $^{1,3}\Pi$ of HI. These bands must be of perpendicular type even though the main B bands look like parallel bands. We can explain this appearance by an electronic angular momentum of 1 unit in the upper state persisting in spite of the C_{3v} symmetry. We further explain certain weak bands of typical but abnormally widely spaced perpendicular structure as due to "forbidden" jumps of ±1 in the quantum number of a-degenerate vibration. These are made weakly allowed by an incipient splitting of the upper electronic level due to removal of the C_{3v} symmetry under the influence of the vibration. An analysis of the observed band structures with the help of infra-red data permits evaluation of the electronic and vibrational angular momenta in the upper state, and also shows that the same moment of inertia increases by 6 percent in the upper state.

* On leave from George Washington University.

30. Spectrum of BiI. S. MROZOWSKI AND F. BUESO-SANLLEHÍ, *University of Chicago.*—The line spectrum of neutral bismuth was photographed in several orders of the 30-foot Chicago grating. A hollow cathode d.c. discharge and a quartz tube with outer electrodes excited by a 4-meter oscillator were used as sources of the spectrum. The hyperfine structure in most of the lines is resolved very completely. Exact measurements of the wave-length and of separation of components were made for all the lines observed. Several new terms were identified. The very high resolving power of the grating permitted the correction of all hyperfine structure term separations previously reported by Zeeman, Back and Goudsmit (13 terms). For some terms results differing considerably from theirs were obtained. The high intensity of the spectrum in case of the short wave excitation made possible the determination of hyperfine structure separations for more than a dozen other terms.

Papers to be read by title.

31. The Extension of Space Group Theory to Submicroscopically Twinned Crystals and its Application to Certain Spinels. F. C. BLAKE, *Ohio State University.*—Space group theory has been extended by the author in the case of certain spinels to submicroscopically twinned structures and a perfect solution has been found in the case of zinc metastannate. Interesting variations of the method employed throw much light upon the correct definition of a "single crystal phase." This is offered as a substitute for the "variate atom equipoint" method of Barth and Posnjak which cannot be right in the case of zinc metastannate for it gives wrong intensity relations. It is confidently believed that submicroscopic twinning is a natural process that occurs in the manufacture of muffles made from refractories and that the two separate cubic structures are revealed when the muffle gives way due to overheating. Undoubtedly this process is an important one occurring in the proper heat treatment of many metal alloys and it must be related to grain size in certain cases at least. It is curious that to date the most important cases of submicroscopic twinning seem to be those of Cochrane [Proc. Phys. Soc. London **48**, 723 (1936)] in the case of pure nickel deposited upon a single crystal of copper and of Kirchner u. Cramer [Ann. d. Physik **33**, 138 (1938)] for gold, nickel and copper deposited upon copper or rocksalt crystals, both cases revealed by electron diffraction.

32. Spectrographic Determination of Traces of Potassium in Sodium. STANLEY S. BALLARD* AND CARROLL B. MILLS, *University of Hawaii.*—The analysis of sodium acetate soil extracts for small amounts of potassium presents a difficult chemical problem. We have developed a successful spectrographic method that uses spark excitation and a one-meter replica grating spectrograph. A highly condensed spark is employed, with a large inductor and an auxiliary point-to-plane spark gap in series with the source gap. The source gap has a pure copper rod as the upper electrode and as a lower electrode, a shallow copper pan in which the solution to be analyzed has been evaporated. Uniform sparking of the salt layer is achieved by manual manipulation of the pan. Photometric measurements are made of the potassium doublet at λ4046 and the λ4102 line of indium, the internal standard element. Analyses are made by adding known amounts of potassium to the liquid samples in repeat runs. With the simple and inexpensive equipment used, the method gives results whose average error is approximately 10 percent. For amounts of potassium less than 5 micrograms, the error is larger. Samples can be analyzed in duplicate at the rate of eight to ten per man-day.

* Now at Bureau of Ordnance, Navy Department, Washington, D. C.

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